9 Spatio-temporal Databases in the Years Ahead

Manolis Koubarakis[1], Yannis Theodoridis[2], and Timos Sellis[3]

[1] Technical University of Crete, Greece
[2] University of Piraeus, Greece
[3] National Technical University of Athens, Greece

9.1 Introduction

CHOROCHRONOS has been a fruitful and enjoyable project. It contributed many innovative ideas in the areas of ontology and data modeling, query evaluation and prototype systems for spatio-temporal databases. Our ideas have already found uses in various application domains such as moving object databases (see Chapter 4), environmental information systems (see the Dedale application in Chapter 5), interactive multimedia applications and virtual worlds (see Chapter 8).

CHOROCHRONOS has opened many avenues for research in spatio-temporal databases, but it also left us with lots of challenging research problems awaiting solution. Many of these problems have already been emphasized in the concluding sections of each chapter, and there is no reason to repeat them here.[1] As an epilogue to this book, we would like to challenge the reader by discussing three important application areas and the role spatio-temporal databases can play in these.

9.2 Mobile and Wireless Computing

The main concept of interest here is the concept of *location* (location of mobile clients, moving application objects and so on) and how it changes over time (a nice recent survey of this area is [10]). This application area has motivated a lot of spatio-temporal research recently (for research carried out outside CHOROCHRONOS see [13,14,4] and [11,6]) but there are many aspects of the problem that have not been looked at in detail. In particular, all approaches seem to adopt a centralized database view of the problem while the problem is clearly distributed [10]. Towards this direction, a recently launched European project [3], where CHOROCHRONOS researchers participate, considers both moving and stationery objects as agents that play the roles of data servers, producers and clients interchangeably. Open issues in all aspects of mobile databases arise under this consideration.

[1] We are sure the seasoned database researcher can easily imagine many others!

T. Sellis et al. (Eds.): Spatio-temporal Databases, LNCS 2520, pp. 345–347, 2003.

9.3 Data Warehousing and Mining

There is currently a huge amount of spatio-temporal data that has been collected over the years. The concept of a data warehouse has naturally been extended from alphanumeric data to temporal, spatial and spatio-temporal data and efficient implementation of OLAP (on-line analytical processing) operations have been studied [7,5,12,8,9]. Of particular interest here is the mining of spatio-temporal patterns, since it can lead to important observations in many applications (e.g., environmental monitoring and fleet management). There is very little work in this area and much remains to be done [15].

9.4 The Semantic Web

According to the Web's inventor Tim Berners-Lee, Jim Hendler and Ora Lassila "the Semantic Web will bring structure to the meaningful content of Web pages, creating an environment where software agents roaming from page to page can readily carry out sophisticated tasks for users." [2,1]. The main technologies underlying this vision are *knowledge representation* and *ontologies* for formalizing meaning, *software agents* as the most useful abstraction for a computational entity and *XML* as the universal language for encoding and sharing information.

There is currently a lot of excitement in this area with much research done under the auspices of W3C[2] and DARPA (e.g., see the effort to develop DAML - DARPA's Agent Markup Language[3]). Ideas from spatio-temporal ontologies, models, languages and query processing algorithms (as discussed in various chapters of this book) cannot really be absent from the Semantic Web vision and there is much interesting research to be carried out by spatio-temporal database researchers.

A related effort is the Geography Markup Language (GML) proposed by the OpenGIS consortium.[4] This is an XML-based language for the storage and transfer of geographic information, including both the spatial and non-spatial properties of geographic objects. This is a good step towards achieving interoperability among existing geographical applications.

9.5 Conclusions

We believe that new applications like the ones sketched above will be the ultimate test for the arsenal of spatio-temporal concepts, models and algorithms developed in CHOROCHRONOS. We invite the reader to join us in taking up the challenge!

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[2] `http://www.w3c.org`.

[3] `http://www.darpa.mil`.

[4] `http://www.opengis.org`.

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